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(71) Applicant (*for all designated States except US*): ITALTEL SOCIETA ITALIANA TELECOMMUNICAZIONI S.P.A.[IT/IT]; Piazzale Zavattari, 12, I-20149 Milan (IT).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*) : BIANCALANA, Alberto [IT/IT]; Via Ser Lapo Mazzei, 13/A, I-50100 Firenze (IT). COLLIVIGNARELLI, Marco [IT/IT]; Via Verdi, 2, I-28040 Dormelletto (IT).

(74) Agent: GIUSTINI, Delio; Italtel Società Italiana Telecomunicazioni S.p.A. , P.O. Box 10, I-20019 Settimo Milanese (IT).

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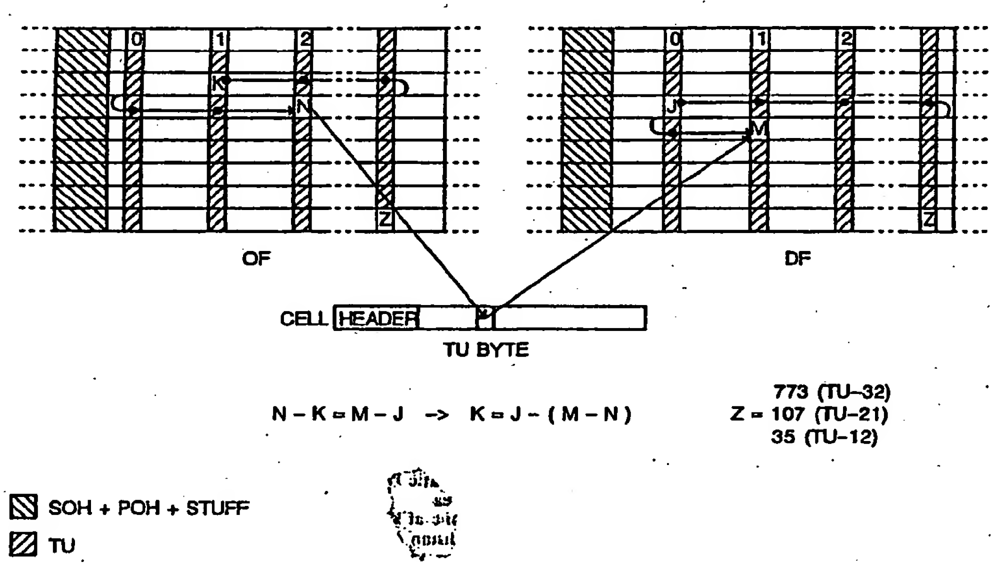

(57) Abstract

Method for the cellization and decellization of a binary data flow including informative structures known as tributary units or TUs, and in particular TU-32, TU-21 and TU-12. Starting from an informative flow set up like an STM-1 frame (corresponding so to the international specifications and norms), through an adaptation operation (Higher Order Path Adaptation), the data flow is structured in an origin byte frame OF (Origin Frame), typically inside a switching node. This frame is cellizised and, after the processing of the information, it is reorganized in a destination byte frame DF (Destination Frame), and from this frame a STM-1 structure is obtained again, which will be transmitted to the following switching node without further elaboration at TU level.

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METHOD FOR THE CELLIZATION AND THE DECELLIZATION OF TRIBUTARY UNITS IN A STM-1 FRAME OF A TELECOMMUNICATION SYSTEM OF THE SYNCHRONOUS DIGITAL HIERARCHY TYPE (SDH)

Technical Field

The present invention concerns a method which allows to transform an informative flow set up in a frame structure of bytes into a frame structure of cells (cellization), and starting from the frame structure realized in this way to provide in output a new frame structure of bytes (decellization).

The invention can be used in digital telecommunication networks, and in particular in telecommunication systems including integrated digital networks in broadband type services (or high bit rate) briefly indicated as B-ISDN.

More in particular the invention concerns optic transmission systems of synchronous digital hierarchy or SDH, which will be used in the evolution from the actual telecommunication systems to those suitable to supply broadband services (B-ISDN).

For the B-ISDN services the use of the transfer and switching system ATM (Asynchronous Transfer Mode) has been specified where the informative flows are subdivided in information blocks of limited amplitude, each of these is carried by a packet or cell of 53 bytes of which 48 are assigned to the information transfer and 5 identify the informative flow to which the cell belongs.

Typically a switching node is a fast packet switch which values the header of each received ATM cell and based on this it routes the cell towards the appropriate ATM flow in output.

In order to overcome certain problems of the actual digital telecommunication networks, which provide for a data transmission of the plesiochronous type, there has recently been a proposal for a synchronous digital

transmission technique called SDH. The SDH technique is based on synchronous transfer modules (STM) where the synchronous transfer module is understood to be an informative structure suitable to support the connections at section level in the SDH system. The STM includes header section fields (SOH) and payloads set up in a block structure which is repeated every 125 μs.

The basic module is defined at a transmission speed or bit rate of 155.520 Mbit/s and is called STM-1. As illustrated in Figure 2A the frame structure of the module or the basic level STM-1 is set up by a matrix of 9 rows and 270 columns and its elements consist of bytes, each one set up by 8 bits, which develops row by row, from the left to the right and from top to bottom. The first 9 columns of the frame include the section header fields (SOH), dedicated for example to the frame alignment, the error monitoring and auxiliary data channels. The remaining 261 columns make up the payload. In the SDH multiplexing in order to create the basic module STM-1 each one of the tributary flows will be processed before entering the payload of the STM-1 module in a way to create the so called Virtual Containers.

The Virtual Container (VC) is an informative structure suitable to transmit information including a payload field called Container (C) and a header field suitable to control the integrity of the informative flow, called Path Overhead (POH). The VCs can be of Higher Order (Higher Order: VC-4, VC-3) or of Lower Order (Lower Order: VC-2 and VC-1). According to the typology of the informative flow carried in the container some of its bytes can be not used, and they are called stuff.

Generally in the case of several tributary flows the STM-1 module carries VCs of Higher Order, while the VCs related to tributary flows are carried in the payload of the VCs of lower order. In the SDH structuring opted for in

Europe the STM-1 module transports a VC-4 in which can be carried VC-32s, VC-21s and VC-12s.

The adaptation between a VC of higher order and the section STM-1 carrying it is realized through an informative structure called Administration Unit (AU). Such administration structure includes an informative part consisting of a VC of higher order and a AU pointer which indicates the position of the VC in the payload area assigned to them inside the module STM-1 as shown in figure 2B. The initial position of the VC of higher order in the STM-1 payload may vary in order to allow the STM-1 module the transfer of the generated VC sometimes with a timing slightly different from that of the STM-1 module itself.

The adaptation between a higher order VC and a VC carried by this one is realized through an informative structure called tributary unit (TU). Such tributary unit includes an informative part made up by the carried VC, and a TU pointer which indicates the position of this in the area of the payload assigned to them inside the VC of higher order indicated in the figure by PTR. The initial position of the carried VC in the payload of the VC of higher order may float in order to allow the latter to convey the generated VC, sometimes with a timing slightly different from that of the VC of higher order.

The TUs can be of various levels indicated by TU-n (where n = 1, 2, 3) set up by a corresponding VC-n and a TU pointer. One or more TU, also of different dimensions, which occupy preset positions in a VC of higher order, form a Group of Tributary Units (TUG-n) where, according to the structuring adopted in Europe, n assumes the values 32, 21. In this way, for example, as illustrated in the multiplexing map of figure 10 the payload of a VC-4 containes 3 TUG-32 of interleaved bytes, where one TUG-32 contains one TU-32 (figure 2C) or it is set up by 7 TUG-21 of interleaved bytes, where in this case a TUG-21 contains

one TU-21 (figure 2D) or 3 TU-12 of interleaved bytes (figure 2E).

In the payload part of a STM-1 the byte arrangement of the VC of higher order and of whatever TU contained in it is repeated identically for each row of the STM-1 flow, so that a TU always turns out to occupy a certain number of columns of the STM-1 frame as described above. Moreover the bytes of the VC of higher order always occupy the same columns of the STM-1 payload, while this does not occur for the TU as the floating of the VC of higher order inside of its columns allows an homogeneous translation within such columns of the columns occupied by the carried TUs.

Since in the telecommunication systems a switching node or switching system operating in ATM technique can receive SDH type informative flows, it is necessary to plan some "conversion" devices or cellizators.

Background Art

A cellizator is a device which accepts in input a frame of whatever composition (for example with VC, in which ATM cells may already be present), and it produces in output a sequence of ATM cells (with header, etc.) which can be handled according to a unique principle (switching of ATM cells). More precisely, a device of this type receives in input an SDH STM-1 informative stream including a VC-4 and inside of this some virtual containers VCs of lower order, which may already contain some ATM cells.

The device carries out the mapping of the TU in ATM cells or the extraction of the ATM cells contained in the VC, after that all cells (those mapping the TUs and those extracted from the VCs) are forwarded to the switching node ATM.

In devices of this type a disadvantage comes up due to the time necessary to collect the number of bytes from the TU to transcribe in the ATM cell before transmitting it. This time called the cellization delay cannot exceed values

preset for each switching node, and therefore in order to avoid unacceptable global delays in the exchange of informations between two subscribers whose signals run through a certain number of switching nodes.

A decellizator carries out an inverted operation allowing the output of the informative flow in direction of the SDH network.

Objects of the Invention

One of the objects of the present invention is to realize a method for the cellization and decellization suitable to minimize the medium delay value of the TUs and to limit the delay dispersion period of the TUs.

Disclosure of Invention

The invention consists of a method for the cellization of binary data flow including informative structures known as tributary units or TUs, and in particular TU-32s, TU-21s and TU-12s,

in which an byte frame structure is generated, set up by a matrix of 9 rows and 270 columns which elements are set up by bytes, each of them consisting of 8 bits, and this frame develops temporally within 125 µs row by row, from left to right and from top to bottom,

in this frame the bytes of one and the same column belong to the same TU, and the bytes corresponding to the same TU occupy one or more intercalated columns in preset positions (from 3 in 3 for the TU-32, from 21 in 21 for the TU-21 and from 63 in 63 for the TU-12 respectively, see figures 2C - 2E);

in this frame a fraction is also included which is equal to one fourth of the pointer of the TUs of lower order, those pointers being supplied entirely in four distinct phases combined with 4 consecutive occurrences of the byte frame structure or in a so called multiframe which occurs within 500 µs, and in each of these appears a part

of the pointer (contained in the V1-V4 bytes for the TU-21s and the TU-12s and in the H bytes for the TU-32s respectively), according to a multiframe synchronism associated to the virtual container or VC which carries the TUs and with common reference for all TUs carried by this,

said method being characterized in that the position of the pointer bytes of the TUs inside the columns of the TUs they belong to, as well as the multiframe phases, are functions of the type of TU they belong to, of the column occupied by the TU in the origin byte frame and of the column occupied by the TU in the destination byte frame.

As an advantage the method generates, starting from the said byte frame structure, a frame structure of 63 cells, each cell being set up by a header and a payload of fixed length or dimension, and this frame develops temporally within 125 µs, and in which the cells corresponding to a same TU occupy one or more preset positions, and that two consecutive cells linked to the same TU are separated by a number of cells (belonging to other TUs) equal to the number of columns existing between two consecutive columns of the said TU in said origin byte frame, except the overhead columns and fixed stuffing.

The method is on the other hand characterized in that said fixed length of the cell is equal to 53 bytes or on the other hand to 418 bits.

The invention consists furthermore of a decellization method for a cell frame structure set up as described above in order to get a destination frame structure of bytes set up by a matrix of 9 rows and 270 columns, which develops temporally within 125 µs row after row, from left to right and from top to bottom,

characterized in that the bytes of the same column belong to the same TU and that the bytes corresponding to a same TU occupy one or more intercalated columns in preset positions, and in that in the said frame there is moreover a fraction contained being equal to one fourth of the

pointer of the TUs of lower order, this pointer being completely supplied in four distinct phases linked to 4 consecutive occurrences of the byte frame structure or in a so called multiframe which develops within 500 μs, in each of which appears one part of the pointer (contained in the V1-V4 bytes for the TU-21s and the TU-12 and in the H bytes for the TU-32s, respectively) according to the multiframe synchronism linked to the virtual container or VC which carries the TUs and with common reference for all TUs carried by this one.

Moreover the invention consists of a method for the phasing of the H pointer bytes corresponding to a tributary unit called TU-32 for the passage from an origin byte frame to a frame structure of 63 packets or cells and consequently to a destination byte frame of a binary data flow in which the H bytes are in a preset position,

the bytes occupied by a generic TU-32 in the origin and the destination byte frames respectively being numbered by an index from 0 to 773 according to the sequence in which those appear in the temporal development of the frame,

characterized in that

for a generic cell respective to a TU-32 and a generic byte of said TU-32 inside of said cell, the relation between the indexes K1 and J1 corresponding to the same H byte for said TU-32, in the origin byte frame and in the destination byte frame is defined by:

$$K1=J1-(M1-N1)+774 \quad \text{for} \quad J1-(M1-N1) < 0$$
$$K1=J1-(M1-N1) \quad \text{for} \quad 0 <= J1-(M1-N1) < 774$$
$$K1=J1-(M1-N1)-774 \quad \text{for} \quad 774 <= J1-(M1-N1)$$

where

M1 is the index of the byte in said TU-32 in the destination byte frame, and

N1 is the index of the byte in said TU-32 in the origin byte frame.

The invention consists further in a method for the phasing of the V pointer bytes corresponding to a tributary unit called TU-21, in the passage from an origin bytes frame to a frame structure of 63 packets or cells, and so to a destination byte frame of a binary data flow in which the V bytes are in a preset standard location,

the bytes occupied by a generic TU-21 in the origin and destination byte frames respectively, numbered by an index from 0 to 107 according to the sequence in which they appear in the temporal development of the frame,

characterized in that

for a generic cell corresponding to a TU-32 and a generic byte of said TU-21 inside said cell, the relation between the indexes K2 and J2 concerning the same V byte for said TU-21, in the origin byte frame and in the destination byte frame respectively,

is defined by:

$$K2=J2-(M2-N2)+108 \quad \text{for} \quad J2-(M2-N2) < 0$$

$$K2=J2-(M2-N2) \quad \text{for} \quad 0 <= J2-(M2-N2) <108$$

$$K2=J2-(M2-N2)-108 \quad \text{for} \quad 108 <= J2-(M2-N2)$$

where

M2 is the index of the byte in said TU-21 in the destination byte frame, and

N2 is the index of the byte in said TU-21 in the origin byte frame.

Finally the invention consists of a method for the phasing of the V pointer bytes corresponding to a tributary unit called TU-12, in the passage from an origin byte frame to a frame structure of 63 packets or cells, and therefore to a destination byte frame of a binary data flow in which the H bytes are in a preset standard location,

the bytes occupied by a generic TU-12 in the origin and destination byte frames respectively, being numbered by an index from 0 to 35 according to the sequence in which they appear in the temporal development of the frame,

characterized in that,

for a generic cell relative to a TU-12 and a generic byte of said TU-12 inside said cell, the relation between the indexes K3 and J3 relating to the same V byte for said TU-12, in the origin byte frame and in the destination byte frame respectively,

is defined by:

$$K3=J3-(M3-N3)+36 \quad \text{for} \quad J3-(M3-N3) < 0$$
$$K3=J3-(M3-N3) \quad \text{for} \quad 0 <= J3-(M3-N3) < 36$$
$$K3=J3-(M3-N3)-36 \quad \text{for} \quad 36 <= J3-(M3-N3)$$

where

M3 is the index of the byte in said TU-12 in the destination byte frame, and

N3 is the index of the byte in said TU-12 in the origin byte.

Brief description of the drawings

The invention will now be described in a more detailed way referring to a preferred but not restrictive form of realization, illustrated by the attached figures in which:

the figures from 1A to 1E illustrate the location of the ATM cells assigned to the transport of the TUs SDH;

the figures from 2A to 2E, already described, illustrate the frame structure of the module or basic level STM-1;

the figures from 3A to 3C illustrate the structure of the STM-1 frame obtained after the Higher Order Path Adoption process;

figure 4 illustrates the cellization process for the TU-12s according to the present invention;

figure 5 illustrates the cellization process for the TU-21s according to the present invention;

figure 6 illustrates the cellization process for the TU-32s according to the present invention;

figure 7 illustrates the decellization process for the TU-12s according to the present invention;

figure 8 illustrates the decellization process for the TU-21s according to the present invention;

figure 9 illustrates the decellization process for the TU-32s according to the present invention;

figure 10 illustrates a multiplexing map of the tributaries in the STM-1 module; and

figure 11 illustrates in a schematic way the method of the present invention.

Detailed description of the preferred embodiment

Now the decellization method will be explained in details according to the invention taking into consideration that for the simplification of the presentation only one portion will be shown in the figures, and more precisely one ninth of the entire local frame which occupies 125 µs. Every 125 µs a frame set up by 63 ATM cells is generated, each one including about 400 bits arranged as illustrated before, where the cells assigned to the transport of a certain TU are always in the same position according to the allocation principle illustrated as follows.

The 63 cells consist of 3 groups of 21 intercalated cells, each one assigned to the transport of the content in one of the 3 TUG-32s, as well shown in figure 1A where the cells numbered by 1, 4, 7, ..., 61 correspond to the TUG-32#1, those numbered by 2, 5, 8, ..., 62 correspond to the TUG-32#2, and those numbered by 3, 6, 9, ..., 63 correspond to TUG-32#3.

Getting down examining each single TUG-32, in case this one contains a TU-32, all 21 cells relating to the TUG-32 they belong to are used for the transport of the last, as illustrated in figure 1B which shows only the cells of one group, marked however by the numbers from 1 to 21 for simplification.

If the TUG-32 contains instead 7 TUG-21, the 21 cells of the TUG-32, they belong to, are arranged in 7 groups of

3 intercalated cells, each one assigned to the transport of what contained in one TUG-21, and shown in figure 1C where again the numbering goes from 1 to 21, and the cells are marked by TUG-21#x, with x=1, 2,...7 according to the group they belong to.

Going further down examining one single TUG-21 (to which only 3 cells are associated), if this contains one TU-21, for the transport of the last all 3 cells relating to the TUG-21, they belong to, are used as illustrated in figure 1D, while in the case the TUG-21 contains 3 TU-12, the 3 cells associated to the TUG-21 they belong to, are arranged in three groups of one cell intercalated, each one assigned to the transport of one TU-12, as illustrated in figure 1E, again indicating by #1, #2 and #3 the TU-12s. Through an adaptation procedure by which the fluctuations of the VC-4 on the TUs contained in them, are discharged, through the new elaboration of the pointers of the last (Higher Order Path Adaptation) the frame shown in figures 3A, 3B and 3C are obtained, where the TUGs and the TUs always occupy the same columns corresponding to the situation of VC-4 in fixed location and not floating within the column they belong to. More precisely, after the Higher Order Path Adaptation procedure corresponding to the pointer situation with null VC-4, the data flow is structured as follows:

- 9 unused bytes, originally occupied by the SOH
- 3 unused bytes originally the first being occupied by the POH VC-4 and the last two by fixed stuff
- 258 payload bytes belonging to the three TUG-32 of 86 bytes, with interleaved bytes.

In the particular case of seven TUG-21 contained in one TUG-32 (shown in the figures 3B and 3C) only the last 84 bytes of the TUG-32 are occupied by seven TUG-21. This situation corresponding to one row of the STM-1 frame is repeated 9 times within the frame of 125 µs.

Generally the position of the pointer bytes of the TUs (known as H bytes for TU-32 and V bytes for TU-12 and TU-21) inside the columns they belong to, turns out to be locked compared to the VC-4.

However, according to the invention, the location of the pointer bytes of the TUs inside the columns they belong to, is different from that normally foreseen (standard position) and indicated in the figure 3A, 3B and 3C by hatched portions and called SPP (Standard Pointer Position). In fact, after the Higher Order Path Adaptation process, the H and V bytes - according to the present invention - occupy in the STM-1 frame particular locations. Furthermore for the TU-12 and the TU-21 the pointer is supplied in 4 distinct phases associated to four consecutive occurrences of the VC-4 in the STM-1 module, in each of which one part of the pointer (V1, V2, V3, V4 bytes) appears, according to a multiframe synchronism associated to the VC-4 (Ha bytes of the POH) and with common reference for all TUs carried by this one.

According to the invention further to the location of the V bytes in the column of the TUs they belong to, also the multiframe phase to which those refer, is generated in an arbitrary way and does not respond to the indication mentioned above, in the sense that for all TU-12 and TU-21 contained in one VC-4 the V byte is of the same type (V1, V2, V3 or V4).

More precisely the position occupied by the H and V bytes in the STM-1 frame and the multiframe phase following to the Higher Order Path Adaptation procedure depends on the type of TU they belong to, on the position occupied by the TU in the input frame, and on the location which the TU must occupy in the output frame, which is generally different from the position occupied in the input frame.

In fact the cellization-decellization process allows to transport by ATM cells whatever TU from an STM-1 origin frame to a STM-1 destination frame, but generally this

involves that the destination frame - even occupying the columns it belongs to - turns out temporally transferred within these columns with the result that the pointer octets do not any more turn out being allocated in the SPP position (Standard Pointer Position) and therefore the TU cannot be correctly handled by eventual SDH transmission devices situated downstream.

The familiar systems - in order to permit the correct processing of the TUs - foresee the presence of adaptation devices connected downstream of the decellizator suitable for the extraction of the VCs from the TUs of the frame, and , upon new pointer elaboration, the TUs are written again with the H and V bytes in standard position. The above mentioned adaptation devices have the inconvenience that they introduce delays and turn out to be expensive, as they need the presence of memory units and pointer elaboration units of analogous complexity necessary in order to execute the Higher Order Path Adaptation procedure.

The method at the basis of the present invention allows instead the elimination of the above mentioned adaptation devices as it foresees the elaboration of the V and H bytes directly within the above mentioned Higher Order Path Adaptation procedure anyhow necessary in SDH switching in order to adapt the TUs to the local system clocking. In particular, according to the invention, if after the cellization-decellization process a TU turns out transferred by N bytes delayed or anticipated, within the columns of the destination frame, during the execution of the Higher Order Path Adaptation procedure of the origin frame, it is written again in the suitable frame (figures 3A, 3b and 3C) with the pointer bytes in advance or with delay of N bytes compared to the standard position so that downstream of the decellization process the pointer bytes will be placed in the SPP position (Standard Pointer Position).

Analogous considerations can be applied within the multiframe of the V bytes for the TU-12 and TU-21 or within the Higher Order Path Adaptation procedure of the origin frame the V bytes are placed in such position in order to respect the correct position within the multiframe in the destination frame.

After having described the adaptation procedure of the STM-1 frame and the ATM frame suitable for the transport of the TUs according to the above mentioned principle, now the principle of information transfer from the STM-1 frame will be described which is adapted to the cells of the ATM frame, previously indicated by the term cellization (cell assembly) which is shown as a graphic example in figure 4 for the TU-12s, in figure 5 for the TU-21s and in figure 6 for the TU-32s.

Referring to the figures 4, 5 and 6 within the last 252 columns of the adapted STM-1 frame there are 63 subdivision defined which divide the 252 columns in 63 contiguous intervals of 36 bytes (63X36 = 2268 bytes). A slot cell of the transmitted ATM frame is rigidly linked to each one of the 63 subdivisions, so that the time sequences of the cells and of the associated subdivisions correspond exactly.

In the figures 4, 5 and 6 the mentioned subdivisions are pointed out by the wording AN, and the ATM cells by the wording CN, where N = 1, ..., 63. Beside that in these figures the header of the ATM cell is defined by H, the overhead OVH of the STM-1 frame by hatched lines inclined to the left, and the unused bytes UCB (Unused Cell Bytes) of the ATM cells by hatched lines inclined to the right.

All the bytes of a TU showing up in the time slot finishing by the subdivision associated to the cell suitable for its transport and beginning by the subdivision associated to the preceding cell for the same TU (cellization time indicated in figures 4, 5 and 6 by the wording CAT = Cell Assembly Time) according to the

mentioned allocation principle of the cells of the ATM frame, are buffered in order to be enclosed in the payload of the ATM cell at the moment of emitting it. In the case of TU-12 and TU-21 in each cellization period there are always 36 bytes, while in the case of TU-32 there are sometimes 36 and sometimes 38 bytes according to a sequence which depends on which cellization periods are associated to the TU-32.

In order to simplify the cellization procedure the same sequence of allocation of the bytes in the following cells is used for all TU-32: 38, 36, 36, 38, 36, 38 and 36 bytes repeated 3 times.

That allows to transcribe only 36 bytes in the ATM cell when sometimes 38 bytes appear in the cellization period and vice versa.

The sequence has been studies in such a way that for all TU-32s having to transcribe 38 bytes in the ATM cell and having collected only 36, it always turns out that the previous cell carried 38 bytes for a cellization period needing only 36, and thus the temporary buffering of 2 bytes which will be transcribed into the following ATM cell is possible. Now the opposite operation of decellization (cell deassembly) will be described, in which, starting from the ATM cell frame generated according to the previous cellization method, an STM-1 frame is reconstructed structured as the starting adapted frame (figures 3A, 3B, 3C) but with the pointer bytes of the TUs in standard position and in a corrected multiframe phase.

The above mentioned decellization procedure is illustrated by graphic presentations of figure 7 for the TU-12s, of figure 8 for the TU-21 and of figure 9 for the TU-32s.

Referring to these figures 7, 8 and 9, within the last 252 columns of the reconstructed STM-1 frame there are 63 contiguous intervals of 36 bytes defined (63X36=2268 bytes). A cell-slot of the received ATM frame is rigidly

linked to each one of the 63 subdivisions as temporary position, in such a way that the temporary sequences of the cells of the associated subdivisions correspond exactly. In figures 7, 8 and 9 the mentioned subdivisions are marked by DN while for the ATM cells, the header of ATM cells (H), the overhead of the STM-1 frame (OVH) and the unused bytes of the ATM cells (UCB) the same previously illustrated graphic symbols with reference to the figures 4, 5 and are used.

The bytes carried by each of the ATM cells are buffered for each TU at the moment of the arrival of the cell and extracted corresponding to the bytes of the TU which occur during the STM-1 frame period which starts the subdivision associated to the actual cell and ends with the subdivision associated to the following cell for the same TU (decellization period indicated in figures 7, 8 and 9 by the wording CDT = Cell Deassembly Time).

In the case of TU-12 and TU-21 in each decellization period there appear always 36 bytes, exactly the number carried by each cell. In the case of TU-32 the bytes asked for in each decellization period do not correspond to the number of bytes received in the relative cell according to the sequence mentioned previously for the cellization, but this sequence is studied in such a way that when for a decellization period 38 bytes are needed and the associated cell carries only 36, it always turns out that the preceding cell carried 38 bytes per decellization period but needing only 36, allowing in this way the temporary buffering of 2 bytes to be used in a following decellizatioin period. In order to make the H bytes of the TU-32s and the V bytes of the TU-12s and TU-21s fall in to the preset standard position in the C-4 it is necessary that in the suitable STM-1 frame before the cellization these are in a proper position inside the column they belong to.

In general if the bytes of a TU after the procedure of cellization turn out transferred by N positions delayed with respect to the original position within the columns, they belong to, the pointer bytes in the STM-1 frame adapted before the cellization must turn out transferred in advance by N positions with respect to the standard position. Besides that, having assigned a multiframe reference for the STM-1 frame set up by the decellization procedure, the V bytes for the TU-12s and TU-21s in the frame adapted before the cellization must be generated according to the multiframe phase corresponding to the frame occurrence in which they will occur in the STM-1 flow set up by the decellization procedure.

Figure 11 summarizes in a synthetic and schematic way the concepts of the invention.

Referring to this figure, starting from an informative flow arranged as an STM-1 frame (and therefore corresponding to the specifications and international standards) the data flow is structured by an adaptation procedure (Higher Order Path Adaptation) into an Origin Frame (OF), typically inside a switching node. These frames are cellizated and, after the processing of the informations, they are rearranged in a Destination Frame (DF), and from this frame an STM-1 structure is obtained again, which is now sent to the following switching node without further processing at TU level.

The cellization modalities according to the invention are illustrated as follows for the TU-32s.

1. The bytes occupied by a generic TU-32 in the origin and in the destination frames respectively, are numbered by an index from 0 to 773 according to the sequence in which those appear in the time development of the frame.

2. For a TU-32 data in the destination frame the index corresponding to an H byte is indicated by J1 (being situated in a preset standard position within the STM-1 frame and in that of the Origin bytes), while the index

corresponding to the same H byte for said TU-332 in the origin frame is indicated by K1.

3. Let's consider a generic cell corresponding to said TU-32 and a generic byte of said TU-32 inside the cell, M1 being the index of this byte in said TU-32 in the destination frame, and N1 being the index of that byte in said TU-32 in the origin frame.

The positional relationship between K1 and J1 is now defined by:

$$K1=J1-(M1-N1)+774 \quad \text{for} \quad J1-(M1-N1) < 0$$
$$K1=J1-(M1-N1) \quad \text{for} \quad 0 <= J1-(M1-N1) < 774$$
$$K1=J1-(M1-N1)-774 \quad \text{for} \quad 774 <= J1-(M1-N1)$$

In the case of TU-21 the bytes taken into consideration are the V bytes and the numbering is done from 0 to 107, and in the above mentioned relation the value 774 is replaced by 108.

In the case of TU-12 the bytes taken into consideration are the V bytes and the numbering is done from 0 to 35, and in the above mentioned relation the value 774 is replaced by 36.

From the point of view of the cellization delay it is evident that whatever will be the chosen allocation for the bytes inside the payload area of the ATM cell provided that it respects the time sequence of arrival of the buffered bytes, sending the cell in a way that the emission of the last used payload byte corresponds to the occurrence of this byte in the cellization period, a minimisation of the cellization-transmission delay of the TU is realized.

However this involves an extreme irregularity of emission of the cells and therefore a consistent needed increase of the transmission speed with scarce exploitation of the transmission channel. This can be reduced by the alignment of the last useful payload byte of the cell with the end of the cellization period as in the example of figures 4, 5 and 6. In this way a minimum increase of the average transmission delay referred to the TUs as a whole,

which in this case can be quantized for the TU-12s of about 122 µs with a maximum variance of about +/- 2.5 µs, for the TU-21s of about 40 µs with a maximum variance of about 1.5 µs and for the TU-32s of about 5.2 µs with a maximum variance of about +/- 0.5 µs.

Finally the emission of the cells can be made absolutely regular by cancelling the last irregularity caused by the overhead of the adapted STM-1 frame through the use of an elastic memory for each TUG-3 in which the bytes of the TU-32 are written (86 columns) or those corresponding to the TU-12s and TU-21s (84 columns) and read again by uniform speed within the 125 µs, aligning the cells in the above mentioned way to the cellization subdivisions carried back into this frame.

Generally it is necessary to average the band availability with the allowed delay, and the last solutions pointed out allow to reduce in an extremely consistent way the necessary band at the cost of a slight increment in the transmission delay.

CLAIMS

1. Method for the cellization of a binary data flow including informative structures known as tributary units or TUs, and in particular TU-32s, TU-21s and TU- 12s,

in which a frame structure of bytes is generated, set up by a matrix of 9 rows and 270 columns which elements is made up by bytes, each one consisting of 8 bits, the frame develops temporally within 125 µs, row after row, from left to right and from top to bottom,

in this frame the bytes of a same column belong to a same TU and the bytes corresponding to a same TU occupy one or more interleaved columns in preset fixed positions (3 by 3 for the TU-32s,21 by 21 for the TU-21s and 63 by 63 for the TU-12s, as shown in figures 1A - 1E).

in this frame there is moreover a fraction contained equal to a fourth of the pointer of the TUs of lower order (TU-21 and TU-12), such pointer being completely issued in 4 separate phases associated to 4 consecutive occurrences of the byte frame structure, or in a so called multiframe which develops within 500 µs in each of which appears a part of the pointer (being contained in the V1-V4 bytes for the TU-21s and the TU-12s and in the H bytes for the TU-32s), according to a multiframe synchronism associated to the virtual container or VC transporting the TUs and with common reference for all TUs transported by this one,

said method being characterized in that the position of the pointer bytes of the TUs inside the columns of the TUs they belong to, as well as the multiframe phase, are functions of the TU type they belong to (TU-32, TU-21 or TU-12), of the position (column) occupied by the TU in the origin byte frame and of the position (column) occupied by the TU in the destination byte frame.

2. Cellization method according to claim 1, characterized in that it generates, starting from the said byte frame structure, a frame structure of 63 packets or

cells, each cell being set up by a header and a payload with fixed length or dimension (L), this frame develops temporally within 125 μs, and in it the cells relative to a same TU occupy one or more fixed preset positions, and in that two subsequent cells associated to the same TU are separated by a number of cells (belonging to other TUs) equal to the number of columns existing between two subsequent columns of said TU in the said origin byte frame, except the overhead columns and fixed stuffing.

3. Cellization method according to claim 2 characterized in that said fix length (L) of the cell is equal to 53 bytes or to 418 bits.

4. Cellization method according to claim 2 or 3 characterized in that said cell frame structure is arranged in 3 groups (G32) of 21 cells, in which the cells of a same group G32 are associated to the same TUG-32 which appear spaced out 3 by 3.

5. Cellization method according to claim 4 characterized in that a control word is associated to each of said G32 groups, relative to the TUG-32, and that it defines the type of content of the TUG, which is used for the construction of the cells relative to each one of said G32 groups.

6. Cellization method according to claim 5, characterized in that the cells relative to one of said G32 groups is set up by assembling a number of consecutive bytes equal to that of the cell dimension (L), which belong to the TU-32 in said input frame structure, excluding the header and stuffing bytes of the TU-32.

7. Cellization method according to claim 5, characterized in that the cells associated to one TU-32 are set up by assembling a number of consecutive bytes belonging to the TU-32 in the frame structure of input bytes according to the following sequence, which will be repeated 3 times: 38 bytes, 36 bytes, 36 bytes, 38 bytes, 36 bytes, 38 bytes, 36 bytes,

and adding to said bytes of useful information a number of stuffing or header bytes in order to reach said fixed length or dimension of the cell.

8. Cellization method according to claim 5 characterized in that the cells belonging to one of said groups (G32) are arranged in 7 groups (G21) of 3 cells, in which the cells of a same group (G21) are associated to the same TUG-21 and they appear spaced out 7 by 7.

9. Cellization method according to claim 8 characterized in that the cells relative to one of said groups (G21) of 3 cells are set up by assembling a number of consecutive bytes equal to said cell dimension (L) belonging to the TU-21 in said input frame structure with the exclusion of the header and stuffing bytes of the TU-21.

10. Cellization method according to claim 8 characterized in that the cells associated to one TU-21 are set up by assembling a number of 36 consecutive bytes belonging to the TU-21 in the frame structure of input bytes adding to said bytes of useful information a number of stuffing and header bytes in order to realize said cell dimension L.

11. Cellization method according to claim 8 characterized in that the cells belonging to one of said groups (G21) of 3 cells are arranged in 3 groups (G12) of 1 cell, said cell being associated to one TU-12.

12. Cellization method according to claim 11 characterized in that the cells relative to one of said groups (TU-12) of one cell are set up by assembling a number of consecutive bytes equal to that of said cell dimension (L) belonging to the TU-12 in said input frame structure, with the exclusion of the header and stuffing bytes of the TU-12.

13. Cellization method according to claim 11, characterized in that the cells associated to one TU-12 are set up by assembling a number of 36 consecutive bytes

belonging to the TU-12 in the frame structure of input bytes, and adding to said bytes of useful information a number of stuffing and header bytes in order to realize said cell dimension (L).

14 Decellization method of a cell frame structure according to claims 1 - 3 in order to obtain a destination byte frame structure set up by a matrix of 9 rows and 270 columns, which develops temporally within 125 μs, row by row, from left to right and from top to bottom,

characterized in that the bytes of a same column belong to the same TU and that the bytes relative to a same TU occupy one or more interleaved columns in a fixed preset position, and in that in said frame a fraction equal to a fourth of the pointer of lower order (TU-21 and TU-12) is contained, this pointer being completely supplied in 4 distinct phases associated to 4 consecutive occurrences of the byte frame structure, or in a so called multiframe which develops within 500 μs, in each one of which one part of the pointer (respectively contained in the V1-V4 bytes for the TU-21s and the TU-12s and in the H bytes for the TU-32s) appears, according to a multiframe synchronism associated to the virtual container or VC, which carries the TUs and with common reference for all TUs carried by this.

15. Decellization method according to claim 14 applied to a cell structure according to claim 6, characterized in setting up a number (L) of consecutive bytes (equal to said cell dimension) belonging to a same TU-32 in said frame structure of output bytes, with the exception of the header and stuffing bytes of the TU-32, using all L bytes of a cell of the G32 group associated to said TU-32.

16. Decellization method according to claim 14 applied to a cell structure according to claim 7, characterized in that a number of consecutive bytes belonging to the same TU-32 in said frame structure of output bytes, is set up by taking into consideration only the cells belonging to said

G32 group associated to said TU-32, extracting from said cell only the information bytes and separating the header and stuffing bytes.

17. Decellization method according to claim 16, characterized in that the cells of said G32 group supply each one a number of said information bytes, according to the following sequence, which is repeated three times: 38 bytes, 36 bytes, 36 bytes, 38 bytes, 36 bytes, 38 bytes, 36 bytes.

18. Decellization method according to claim 14 applied to a cell structure according to claim 9, characterized in that a number (L) (equal to said cell dimension) of consecutive bytes belonging to the same TU-21 in said frame structure of output bytes, with the exception of the header and stuffing bytes of the TU-21, is set up using all L bytes of a cell of said G21 group associated to said TU-21.

19. Decellization method according to claim 14 applied to a cell structure according to claim 10, characterized in that 36 consecutive bytes belonging to one TU-21 in the frame structure of output bytes are assembled by extracting from each cell relative to one of said G12 groups the 36 information bytes and putting aside the header and stuffing bytes.

20. Decellization method according to claim 14 applied to a cell structure according to claim 11, characterized in that a number (L) (equal to said cell dimension) of consecutive bytes belonging to the same TU-12 in said frame structure of output bytes, with the exception of the header and stuffing bytes of the TU-12, is set up by using all L bytes of a cell of said G12 group associated to said TU-12.

21. Decellization method according to claim 14 applied to a cell structure according to claim 13, characterized in that 36 consecutive bytes belonging to one TU-12 in the frame structure of output bytes are assembled by extracting from each cell relative to one of said G12 groups the 36

information bytes and putting aside the header and stuffing bytes.

22. Method for the positioning of the H pointer bytes relative to a tributary unit called TU-32s, in the passage from an origin byte frame to a frame structure of 63 packets or cells, and thus to a destination byte frame of binary data flow where the H bytes are in a preset standard position,

the bytes occupied by a generic TU-32 in the origin and destination byte frames respectively, being numbered by an index from 0 to 773 according to the sequence in which those appear in the temporal development of the frame,

characterized in that,

for a generic cell relative to a TU-32 and a generic byte of said TU-32 inside of said cell, the relation between the indexes K1 and J1, relative to the same H bytes for said TU-32, respectively in the origin byte frame and in the destination byte frame, is defined by:

$$K1 = J1-(M1-N1)+774 \quad \text{for} \quad J1-(M1-N1) < 0$$
$$K1 = J1-(M1-N1) \quad \text{for} \quad 0 <= J1-(M1-N1) < 774$$
$$K1 = J1-(M1-N1)-774 \quad \text{for} \quad 774 <= J1-(M1-N1)$$

where

M1 is the index of the byte in said TU-32 in the destination byte frame, and

N1 is the index of the byte in said TU-32 in the origin byte frame.

23. Method for the positioning of the V pointer bytes relative to a tributary unit called TU-21, in the passage from an origin byte frame to a frame structure of 63 packets or cells, and thus to a destination byte frame of a binary data flow in which the V bytes are in a preset standard position,

the bytes occupied by a generic TU-21 in the origin or destination byte frames respectively, being numbered by an index from 0 to 107 according to the sequence in which these appear in the temporal frame development,

characterized in that,

for a generic cell relative to a TU-32 and a generic byte of said TU-21 inside said cell, the relation between the indexes K2 and J2, relative to the same V byte for said TU-21, in the origin byte frame and in the destination byte frame respectively,

is defined by:

K2=J2-(M2-N2)+108	for	J2-(M2-N2) < 0
K2=J2-(M2-N2)	for	0 <= J2-(M2-N2) < 108
K2=J2-(M2-N2)-108	for	108 <= J2-(M2-N2)

where

M2 is the index of the byte of said TU-21 in the destination byte frame, and

N1 is the index of the byte in said TU-21 in the origin byte frame.

24. Method for the positioning of the V pointer bytes relative to a tributary unit called TU-12, in the passage from an origin byte frame to a destination byte frame structure in a binary data flow where the H bytes are in a preset standard position,

the bytes occupied by a generic TU-12 in the origin and destination byte frames respectively, being numbered by an index from 0 to 35 according to the sequence in which these appear in the temporal development of the frame,

characterized in that,

for the generic cell relative to a TU-12 and a generic byte of said TU-12 inside said cell, the relation between the indexes K3 and J3, relative to the same V byte for said TU-12, in the origin byte frame and in the destination byte frame respectively,

is defined by:

K3=J3-(M3-N3)+36	for	J3-(M3-N3) < 0
K3=J3-(M3-N3)	for	0 <= J3-(M3-N3) < 36
K3=J3-(M3-N3)-36	for	36 <= J3-(M3-N3)

where

M3 is the index of the byte in said TU-12 in the destination byte frame, and
N3 is the index of the byte in said TU-12 in the origin byte frame.

25. Device for the data cellization which carries out the method according to whatever of the previous claims.

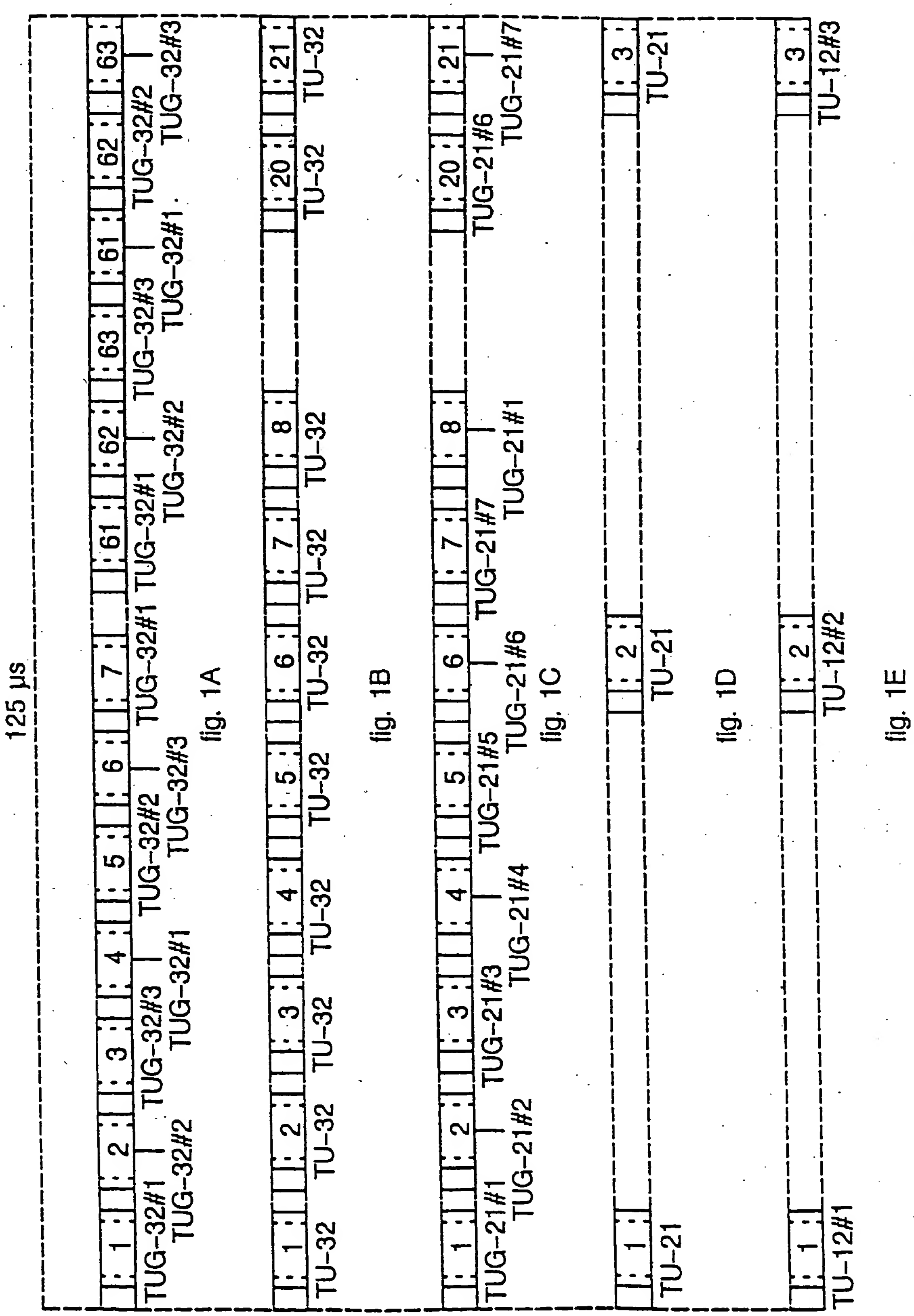


fig. 1A

fig. 1B

fig. 1C

fig. 1D

fig. 1E

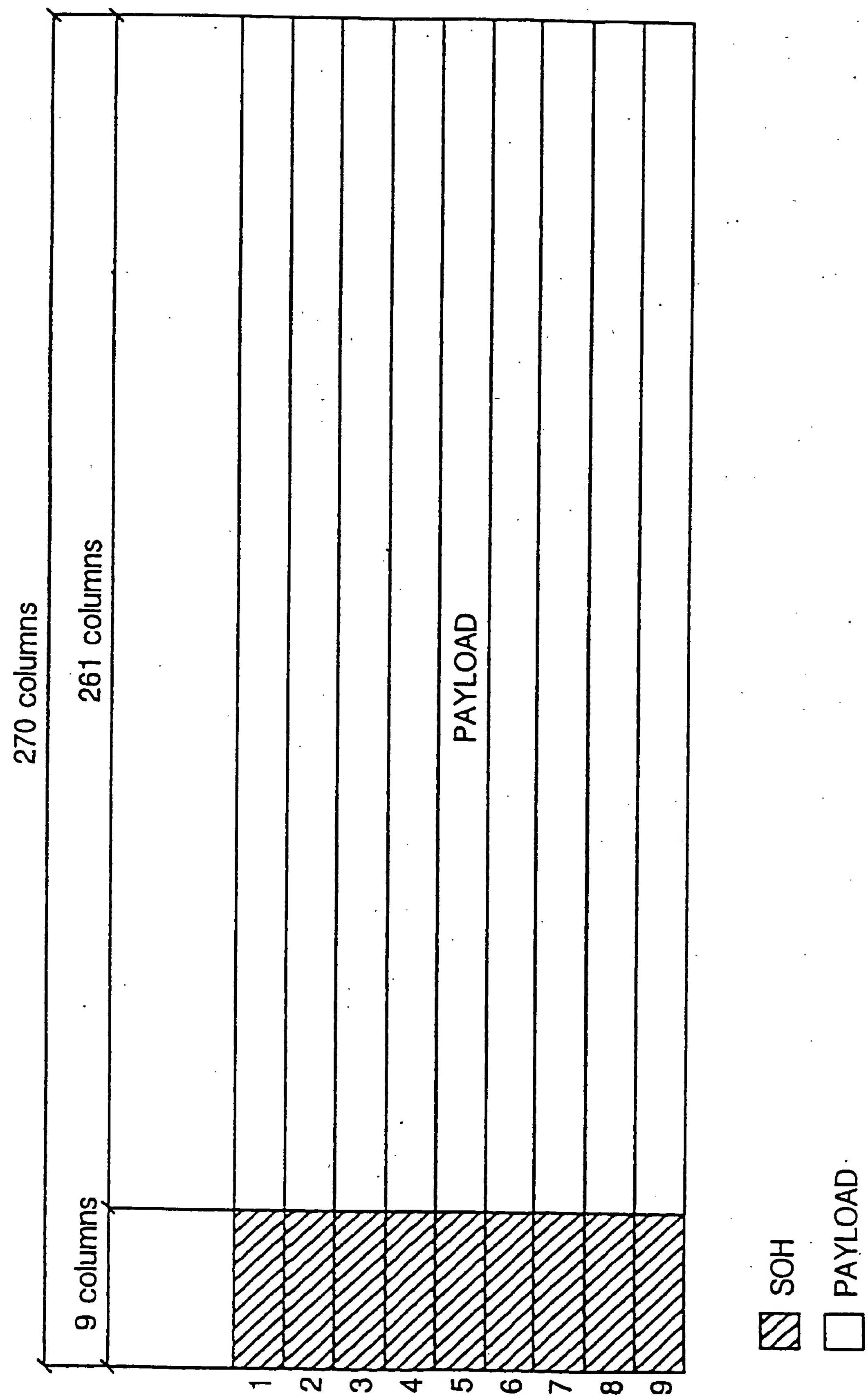
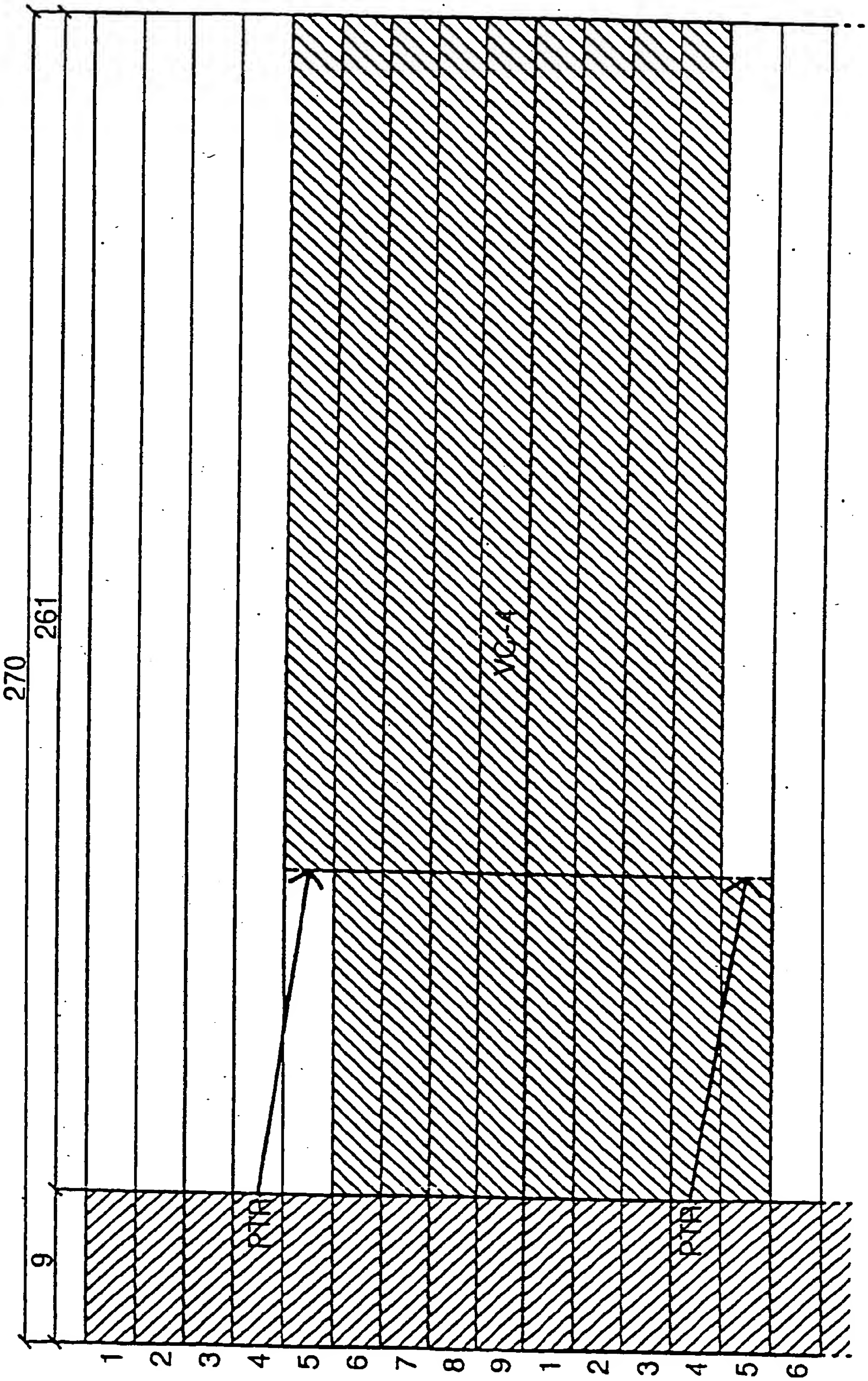

270 columns
261 columns
9 columns
PAYLOAD
1
2
3
4
5
6
7
8
9
SOH
PAYLOAD

fig. 2A



SOH PAYLOAD VC-4

VC4 : 9 rows X 261 columns

fig. 2B

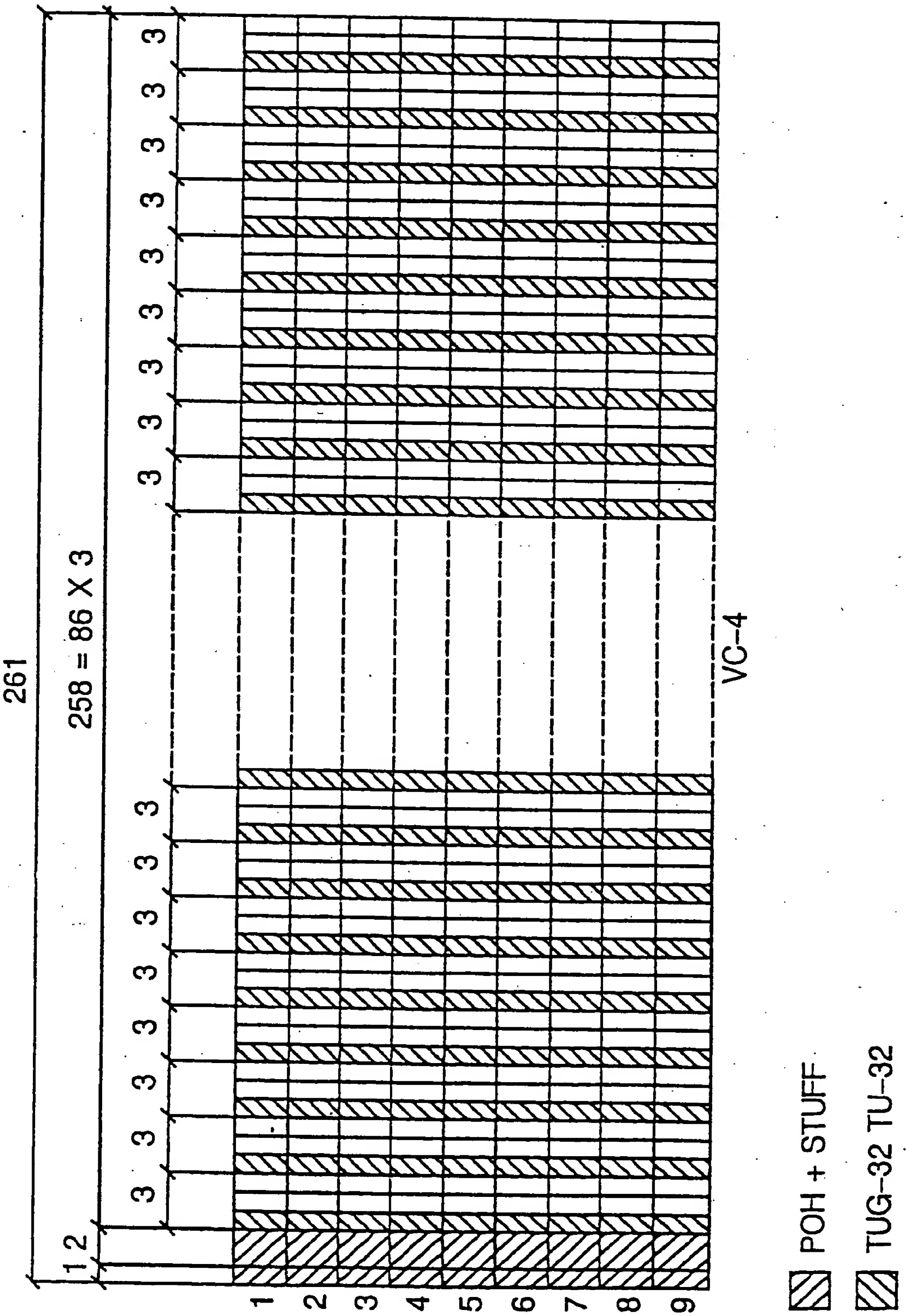


fig. 2C

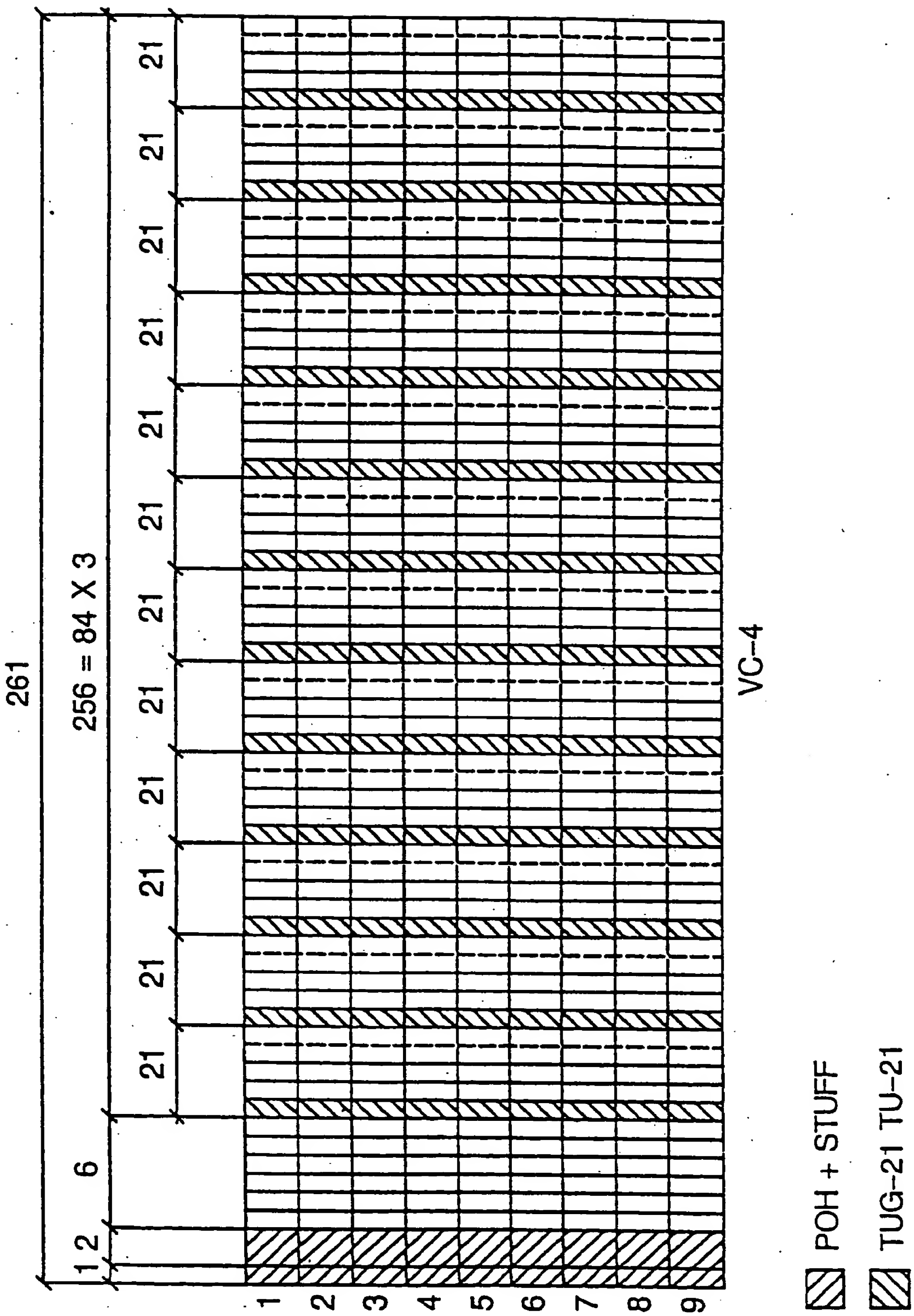

261
256 = 84 X 3
1
2
6
21
21
21
21
21
21
21
21
21
21
21
21
1
2
3
4
5
6
7
8
9
VC-4
POH + STUFF
TUG-21 TU-21

fig. 2D

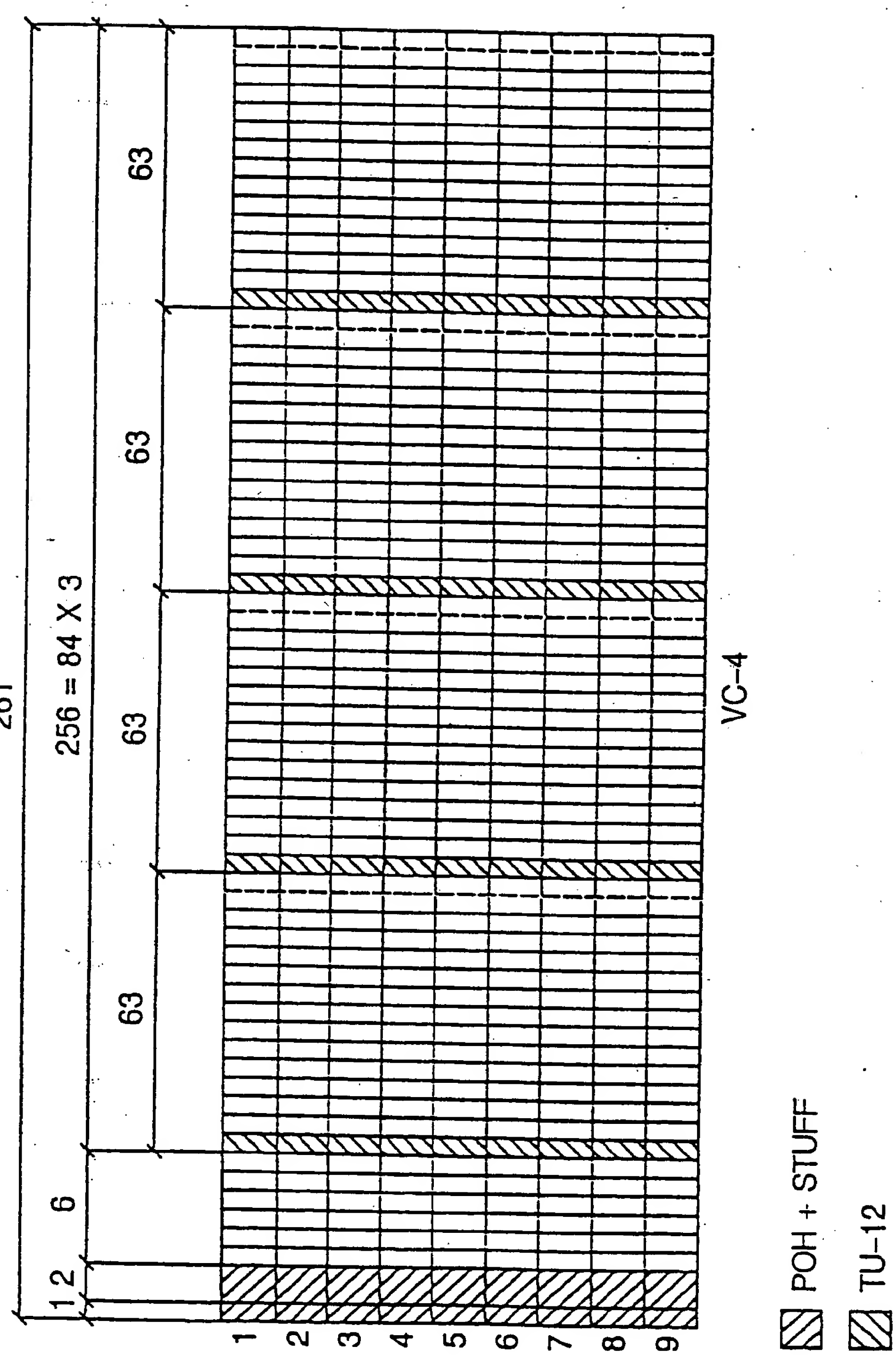


fig. 2E

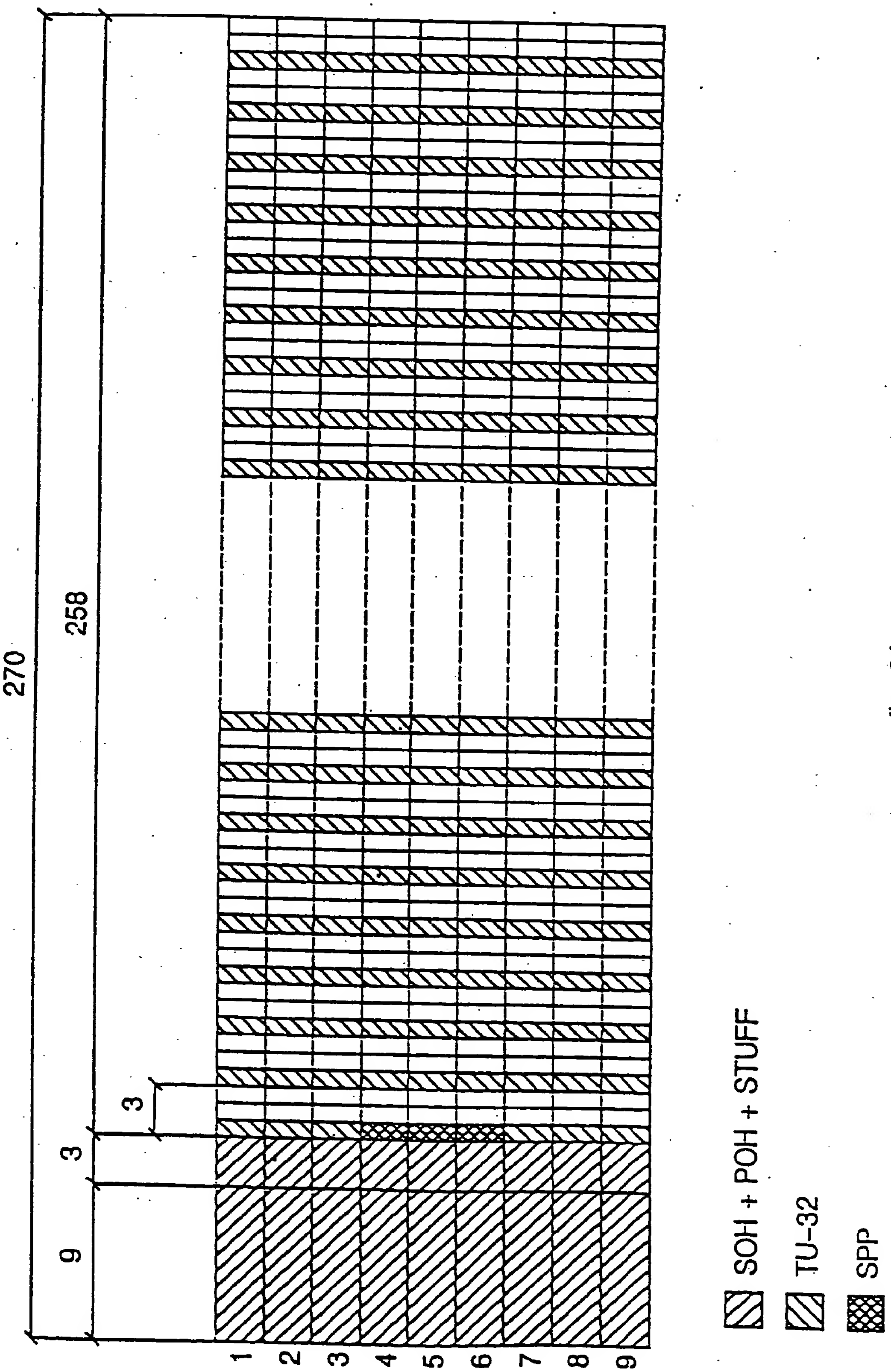


fig. 3A

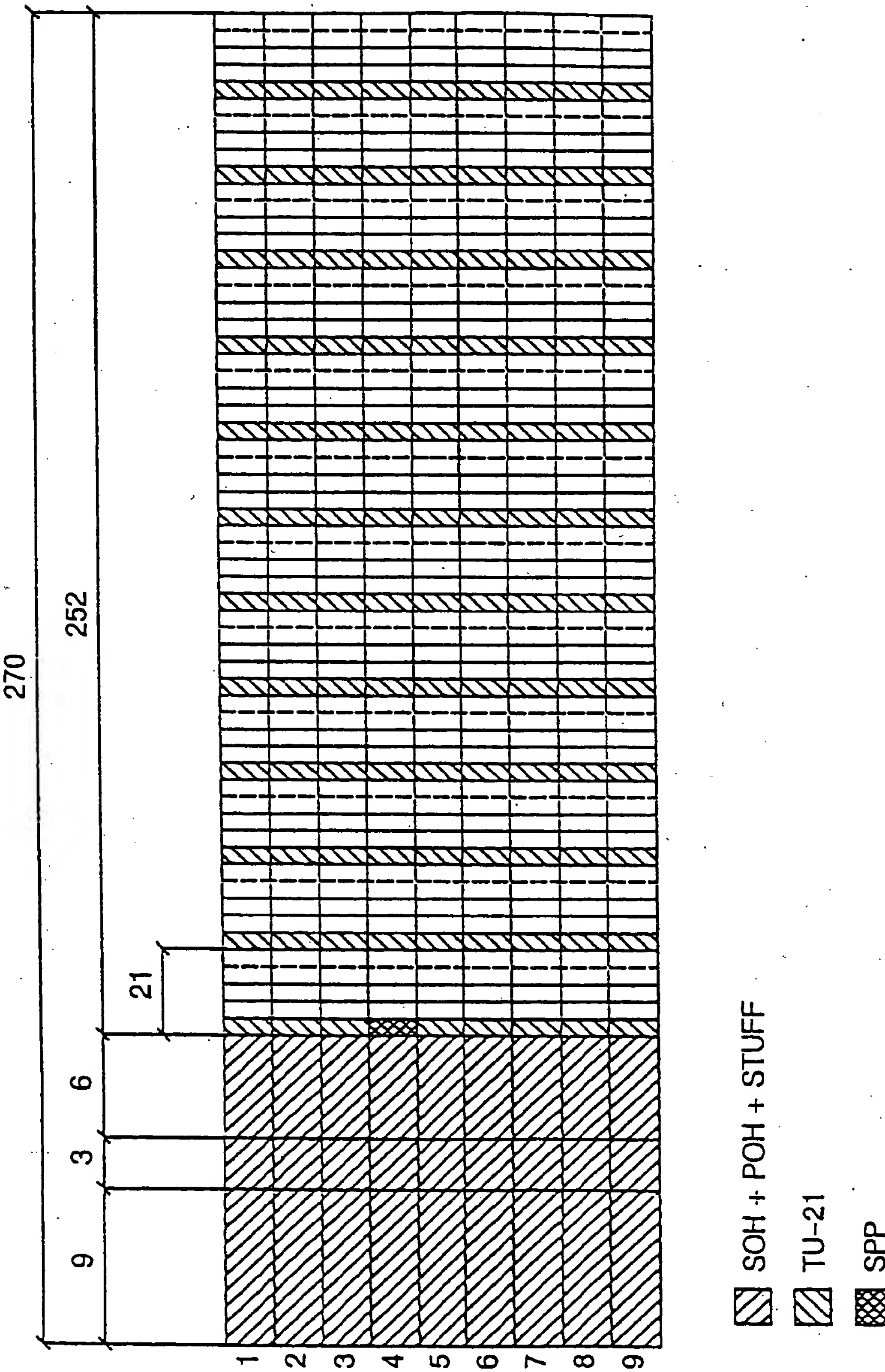


fig. 3B

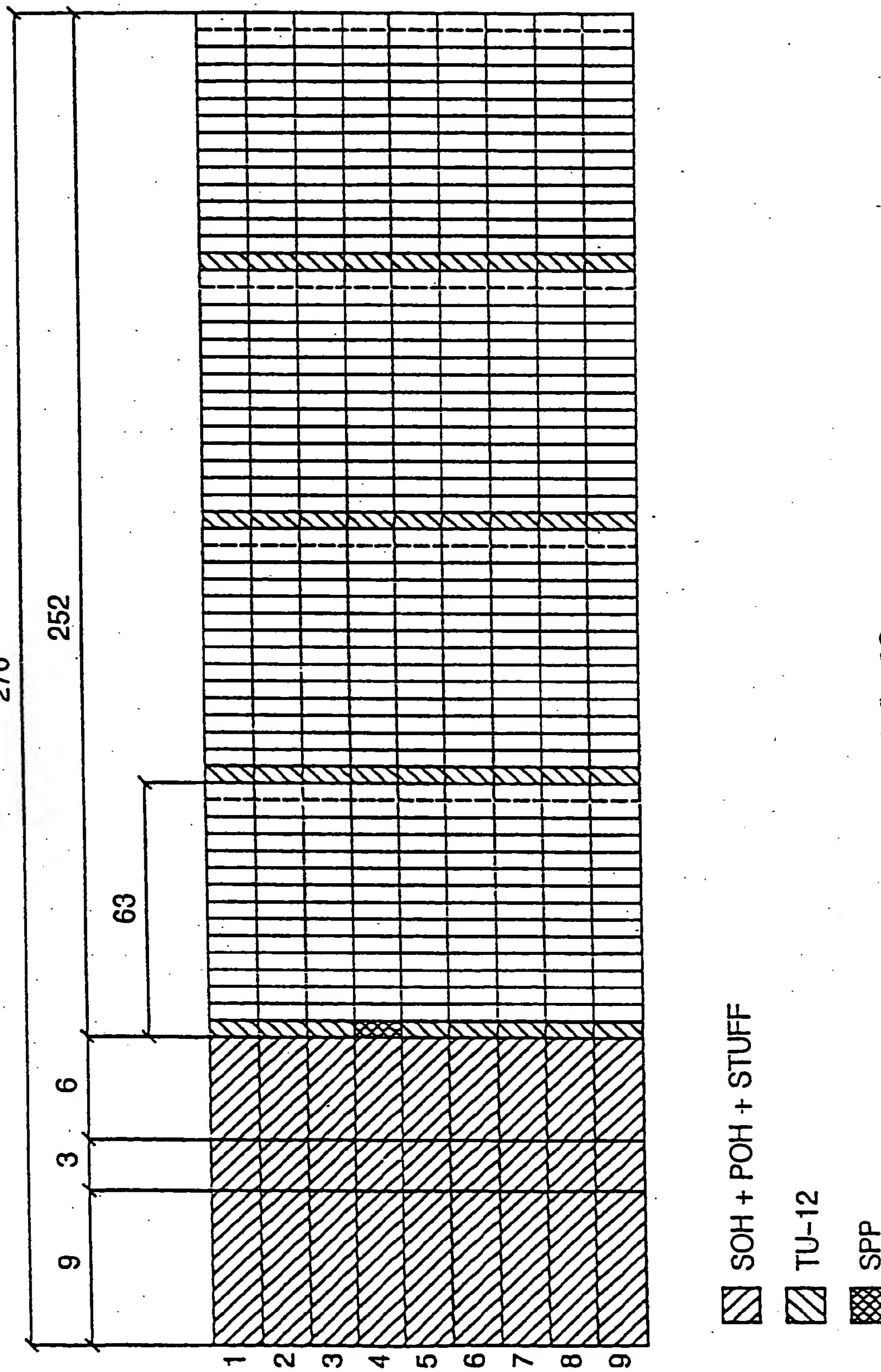


fig. 3C

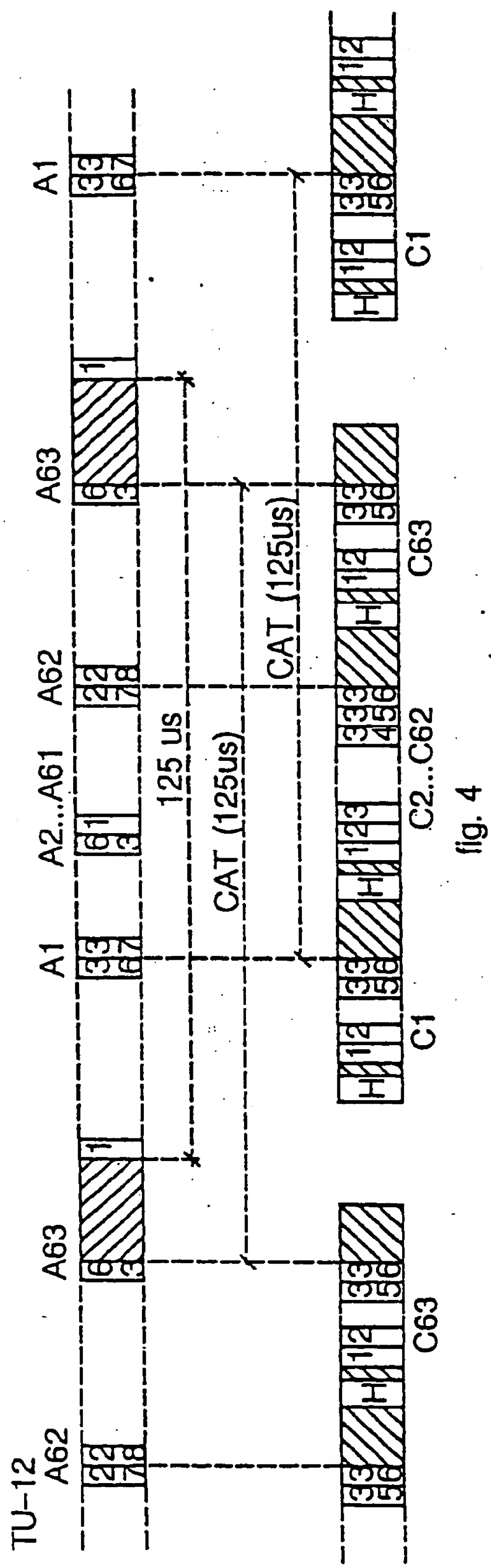

TU-12
A62
A63
A1
A2...A61
A62
A63
A1
125 us
CAT (125us)
CAT (125us)
C63
C1
C2...C62
C63
C1

fig. 4

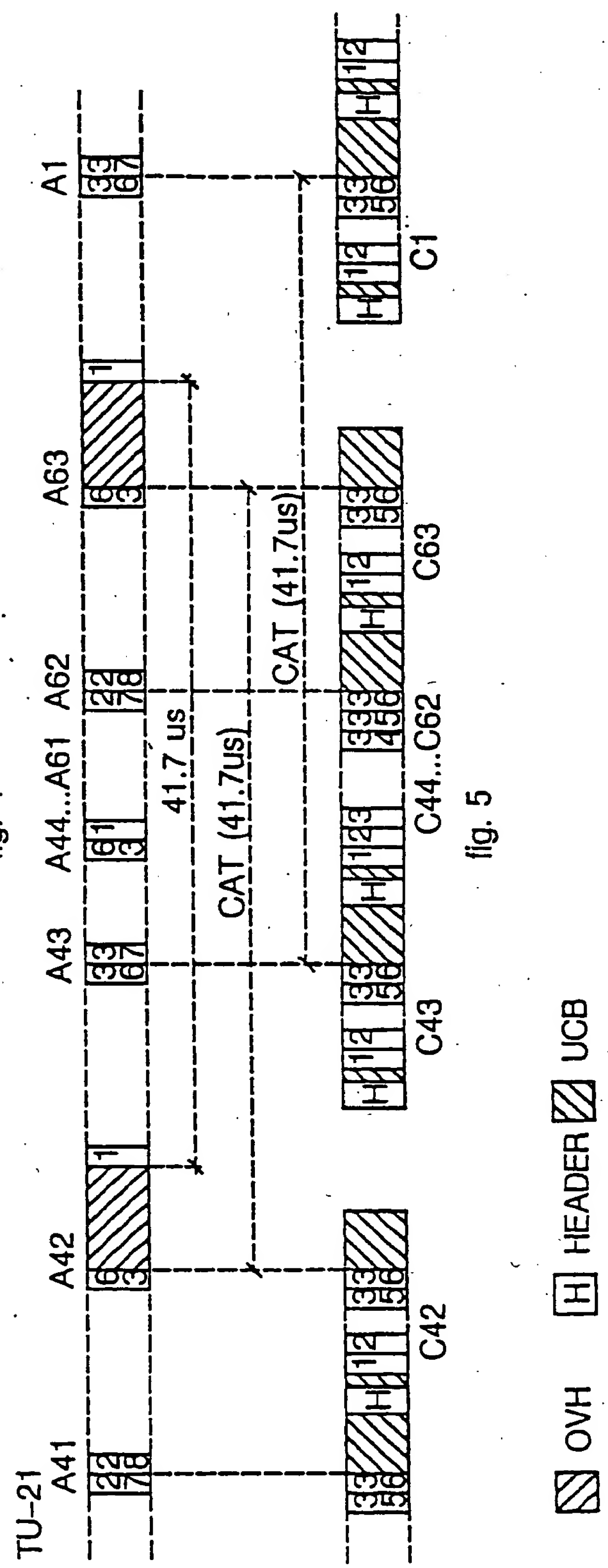

TU-21
A41
A42
A43
A44...A61
A62
A63
A1
41.7 us
CAT (41.7us)
CAT (41.7us)
C42
C43
C44...C62
C63
C1
OVH
H HEADER
UCB

fig. 5

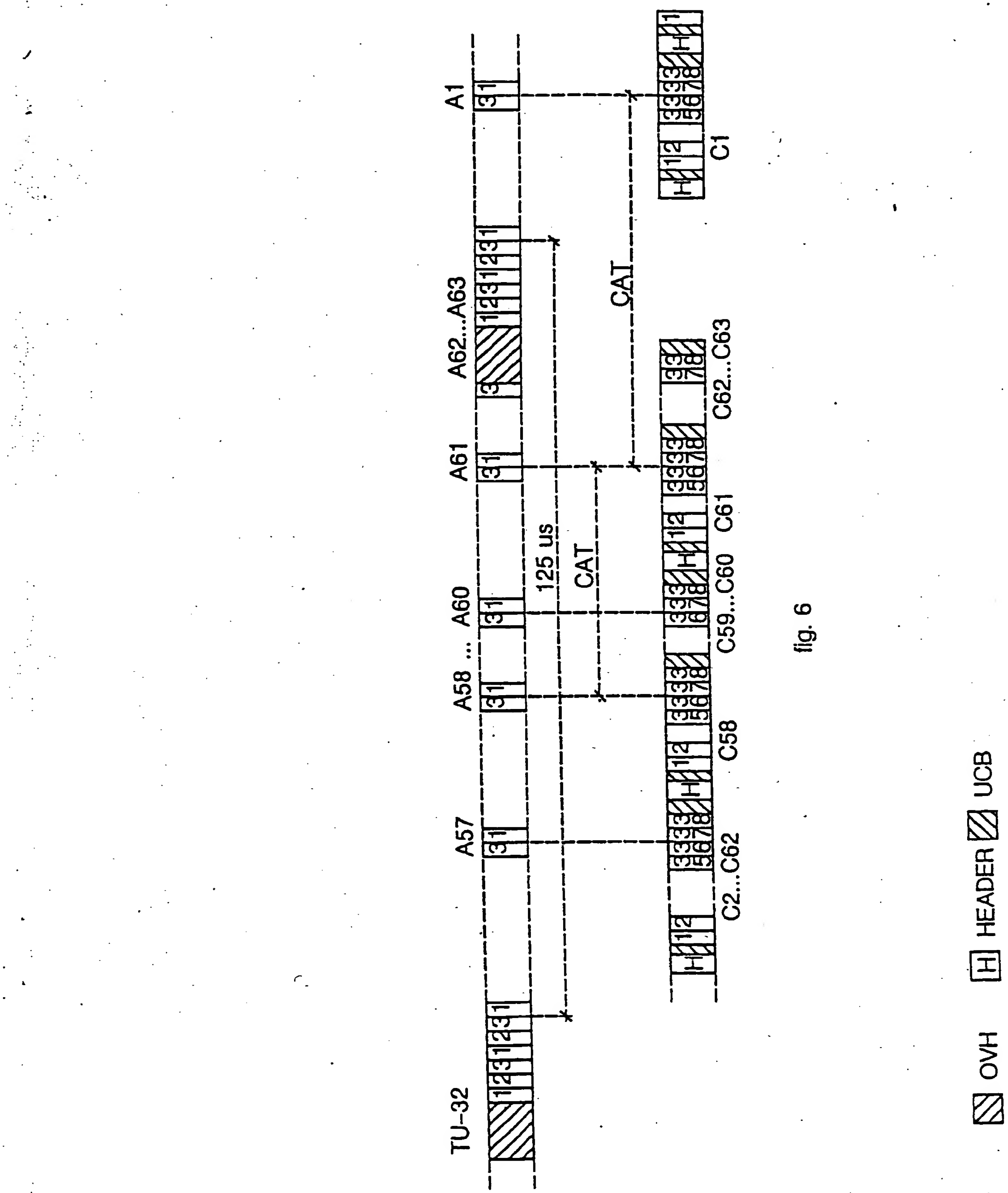

TU-32
A57
A58 ...
A60
A61
A62...A63
A1
125 us
CAT
CAT
C2...C62
C58
C59...C60
C61
C62...C63
C1
OVH
H HEADER
UCB

fig. 6

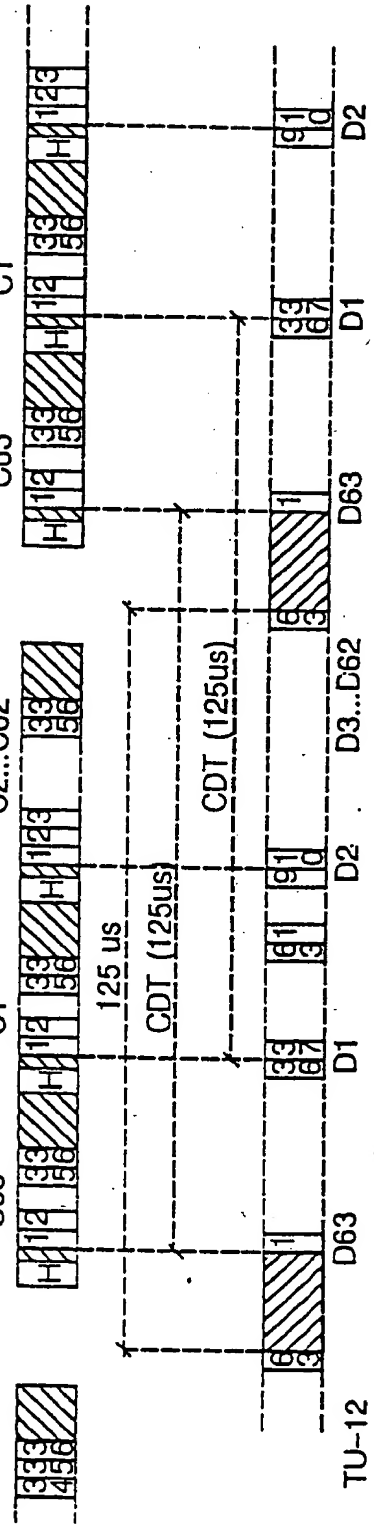

C63
C1
C2...C62
C63
C1
C2
TU-12
D63
D1
D2
D3...D62
D63
D1
D2
125 us
CDT (125us)
CDT (125us)

fig. 7

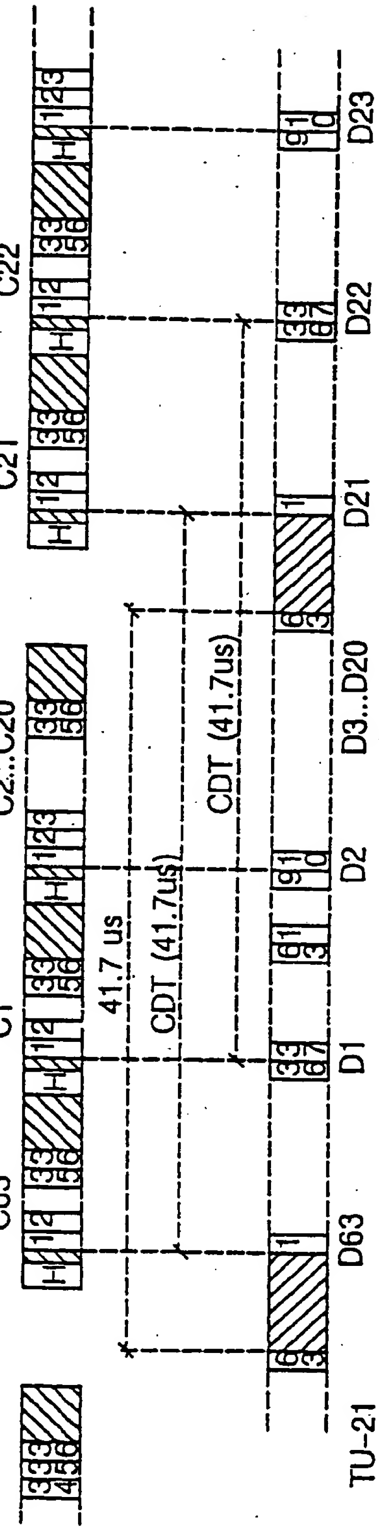
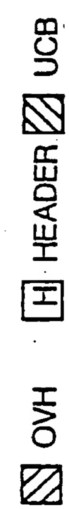

C63
C1
C2...C20
C21
C22
TU-21
D63
D1
D2
D3...D20
D21
D22
D23
41.7 us
CDT (41.7us)
CDT (41.7us)

fig. 8


OVH
H HEADER
UCB

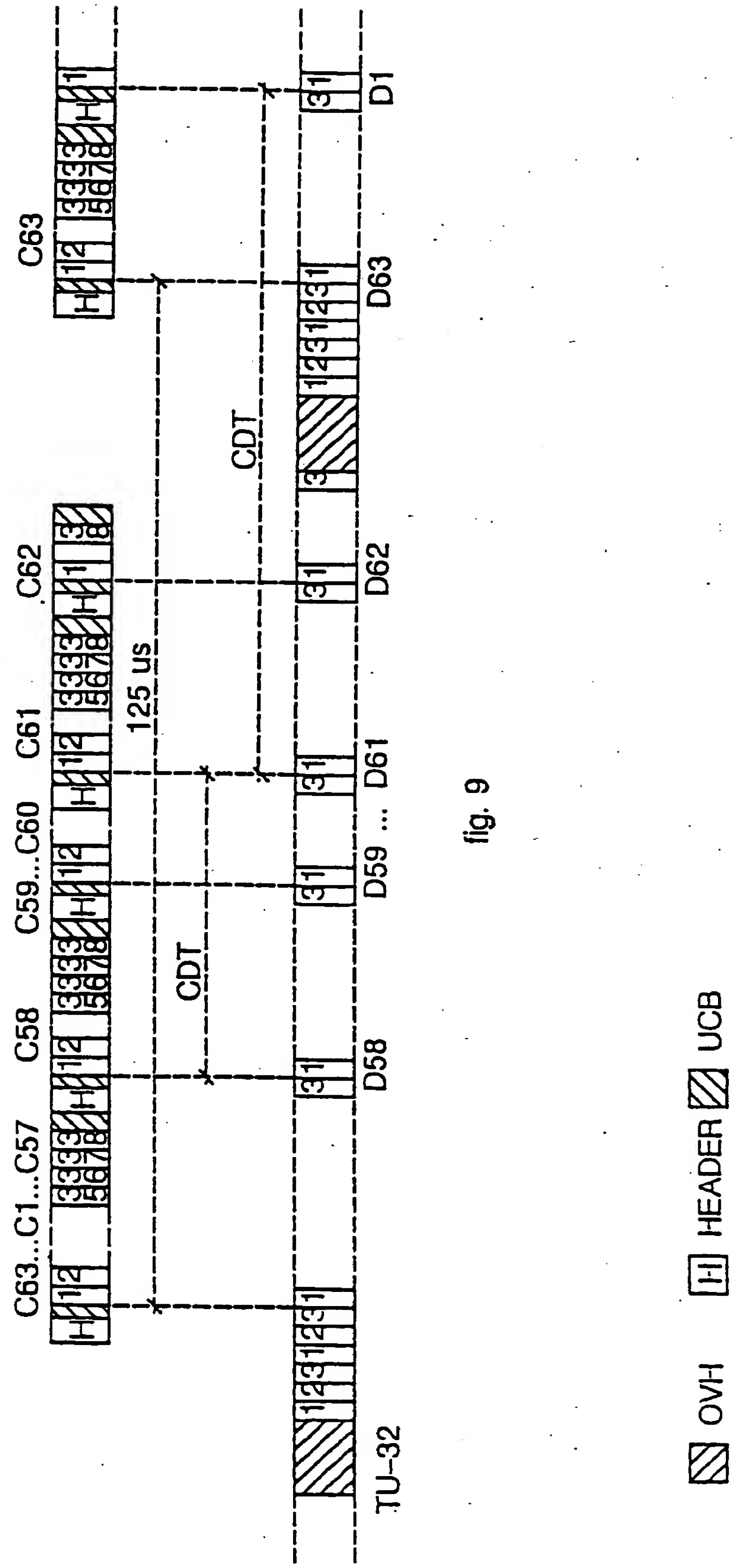

C63..C1...C57
C58
C59...C60
C61
C62
C63
125 us
CDT
CDT
TU-32
D58
D59 ... D61
D62
D63
D1
OVH
HEADER
UCB

fig. 9

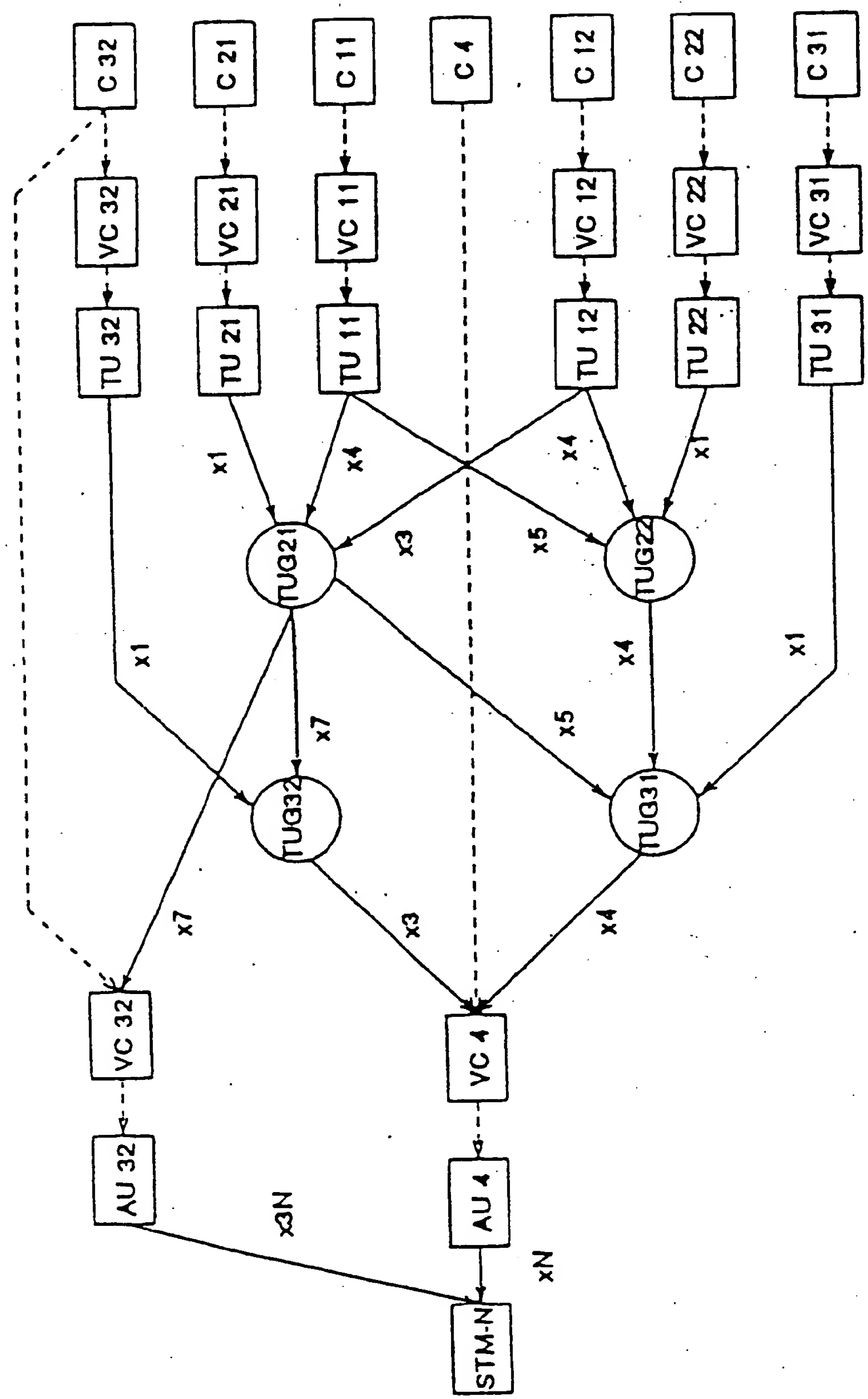

C 32
C 21
C 11
C 4
C 12
C 22
C 31
VC 32
VC 21
VC 11
VC 12
VC 22
VC 31
TU 32
TU 21
TU 11
TU 12
TU 22
TU 31
x1
x4
x4
x1
x3
x5
TUG21
TUG22
x1
x7
x5
x4
x1
TUG32
TUG31
x7
x3
x4
VC 32
VC 4
AU 32
AU 4
x3N
xN
STM-N

fig. 10

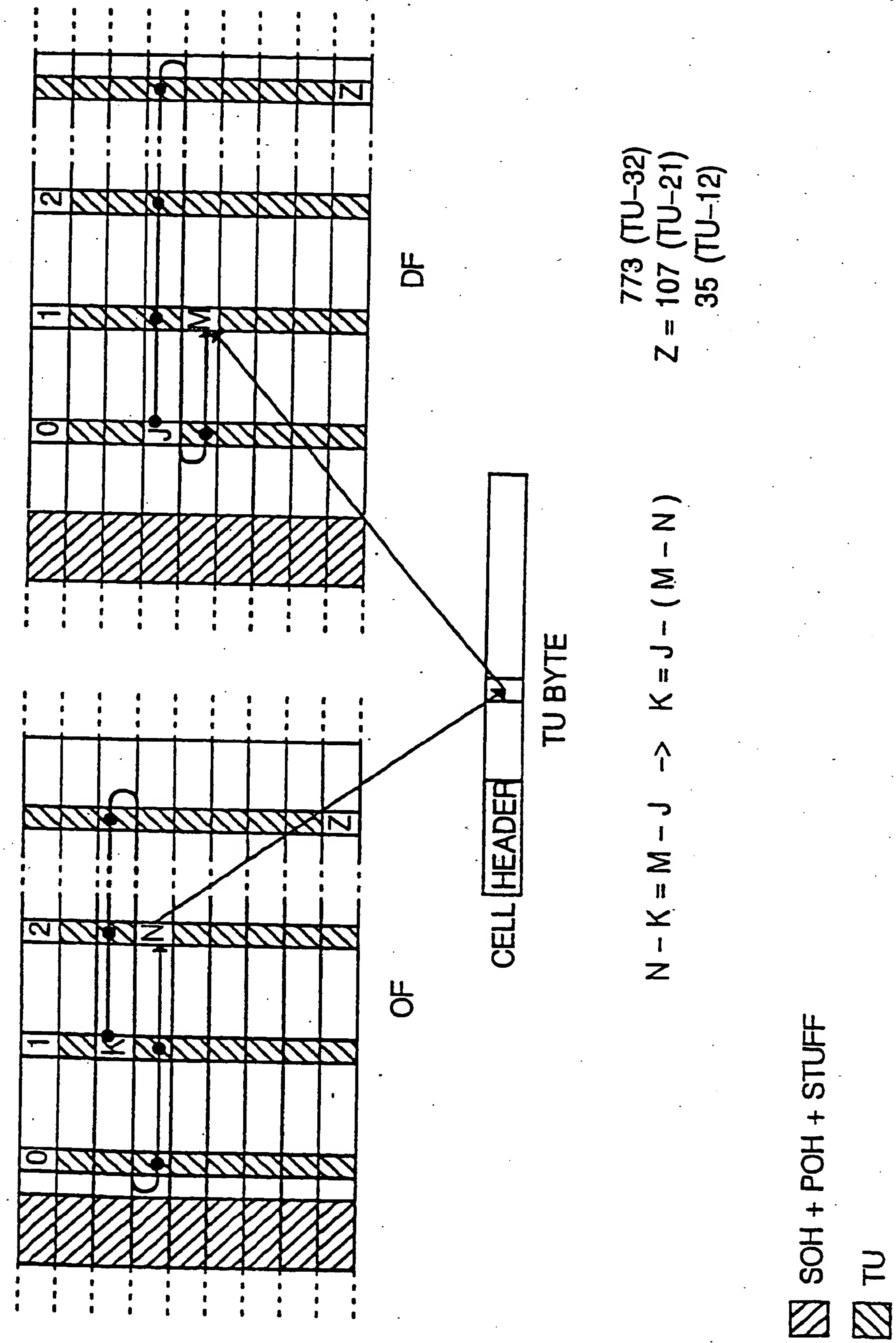

DF
OF
CELL HEADER
TU BYTE
0
1
2
Z
J
M
K
N
773 (TU-32)
Z = 107 (TU-21)
35 (TU-12)
N - K = M - J -> K = J - (M - N)
SOH + POH + STUFF
TU

fig. 11

INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 93/01674

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 H04J3/16

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	H04J

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	EP,A,0 468 818 (NEC CORPORATION) 29 January 1992 see column 1, line 49 - column 2, line 21 see column 3, line 25 - column 4, line 28 ---	1,22,23, 24
A	EP,A,0 342 510 (SIEMENS AKTIENGESELLSCHAFT) 23 November 1989 see column 1, line 33 - column 2, line 13 see column 2, line 31 - column 3, line 19 ---	1

-/--

° Special categories of cited documents :[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

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IV. CERTIFICATION

1

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
13 OCTOBER 1993	22.10.93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	VAN DEN BERG J.G.J.

International Application No PCT/EP 93/01674

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	CCITT RECOMMENDATION I.432 5 April 1991, GENEVE (CH) pages 5 - 6 NOMEN NESCIO 'Integrated services digital network (ISDN);Overall network aspects and functions,ISDN user-network interfaces; B-ISDN user-network interface - physical layer specification' see page 5, line 1 - page 6, line 4	1

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

EP 9301674
SA 76549

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 13/10/93
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0468818	29-01-92	JP-A- 5007219	14-01-93
EP-A-0342510	23-11-89	None	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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